

```
In [ ]: import networkx as nx
```

```
#Load GraphMissingEdges  
G = nx.read_gml("../GraphMissingEdges.gml")
```

```
In [ ]: def compute centrality(centrality_callback):  
    # Compute degree centrality  
    degree Centrality = centrality_callback(G)  
  
    # Sort nodes by degree centrality and get top 50  
    top_50_degree Centrality = sorted(degree Centrality.items(), key=lambda x: x  
  
    # Print top 50 places with their categories  
    print("Top 50 places according to centrality:")  
    for node, centrality in top_50_degree Centrality:  
        print(f"Place: {G.nodes[node].get('name', 'Empty')}")  
        print(f"Centrality: {centrality}")  
        print(f"Categories: {G.nodes[node]['categories']}\n")
```

1- Usando a rede do desafio "GraphMissingEdges.gml", faça o que é pedido abaixo.

a- Compute a centralidade de grau e identifique os top 50 lugares de acordo com essa métrica. Mostre o nome e categorias dos lugares.

```
In [ ]: compute Centrality(nx.degree Centrality)
```

Top 50 places according to centrality:

Place: Gaucho Parrilla Argentina

Centrality: 0.050721469173589856

Categories: 221,64,1,83

Place: Condado Tacos

Centrality: 0.04897245299519021

Categories: 1,393,275,208,58,651

Place: Noodlehead

Centrality: 0.04634892872759073

Categories: 370,1,620,641

Place: tākō

Centrality: 0.04459991254919108

Categories: 1,420,651

Place: Bakersfield

Centrality: 0.04175776125929165

Categories: 58,275,393,208,420,83,651,1

Place: Smallman Galley

Centrality: 0.040008745080892

Categories: 275,604,420,173,1,58,641

Place: Meat & Potatoes

Centrality: 0.03738522081329253

Categories: 428,641,262,490,420,1,188

Place: DiAnoia's Eatery

Centrality: 0.03694796676869261

Categories: 1,287,289,405

Place: Piada Italian Street Food

Centrality: 0.034324442501093136

Categories: 741,1,405,46

Place: Banh Mi & Ti

Centrality: 0.028858766943594228

Categories: 1,362,857,204,641

Place: Pork & Beans

Centrality: 0.028421512898994316

Categories: 604,1,208,612,58,275,437,706,133,641,289,613,330

Place: Social House Seven

Centrality: 0.027984258854394404

Categories: 1,861,791,870,550

Place: Millie's Homemade Ice Cream

Centrality: 0.027547004809794492

Categories: 1,289,641,653

Place: Southern Tier Brewery Pittsburgh

Centrality: 0.026672496720594668

Categories: 58,201,1,100,275,641,188

Place: City Works - Pittsburgh

Centrality: 0.025360734586794928

Categories: 420,100,612,604,1,58,341,275

Place: The Porch at Schenley
Centrality: 0.024267599475295148
Categories: 1,602,289,82,248,420

Place: Altius
Centrality: 0.024048972452995192
Categories: 133,641,1,275,5,58,420,575

Place: The Abbey on Butler Street
Centrality: 0.02361171840839528
Categories: 275,420,362,641,1,58,173

Place: Muddy Waters Oyster Bar
Centrality: 0.022955837341495408
Categories: 208,275,58,354,1,83

Place: Burgh'ers Brewing
Centrality: 0.022518583296895496
Categories: 248,420,133,641,289,1,741,706,127,201

Place: Mindful Brewing Company
Centrality: 0.02229995627459554
Categories: 641,201,696

Place: Pirata
Centrality: 0.02229995627459554
Categories: 289,208,817,58,275,1

Place: Primanti Bros
Centrality: 0.022081329252295584
Categories: 289,1,618,341,275,501,58,420

Place: Proper Brick Oven & Tap Room
Centrality: 0.021862702229995628
Categories: 405,641,696,58,1,82,275

Place: Butcher and the Rye
Centrality: 0.021644075207695672
Categories: 694,275,420,208,58,641,1

Place: Church Brew Works
Centrality: 0.020988194140795804
Categories: 275,1,58,201,604,575,641

Place: Totopo Mexican Kitchen and Bar
Centrality: 0.020988194140795804
Categories: 275,1,64,58,651

Place: Ki Ramen
Centrality: 0.020769567118495848
Categories: 1,620,661,870,275,58

Place: Deluca's Diner
Centrality: 0.020113686051595976
Categories: 162,594,604,1

Place: Redhawk Coffee
Centrality: 0.019676432006996064
Categories: 1,162,344,173,575,641

Place: Everyday Noodles
Centrality: 0.01880192391779624
Categories: 631,620,791,1

Place: Hofbrauhaus Pittsburgh
Centrality: 0.018583296895496284
Categories: 641,275,100,829,1,201,855,58

Place: Smoke BBQ Taqueria
Centrality: 0.018364669873196328
Categories: 1,613,248,651,393

Place: Primanti Bros
Centrality: 0.018364669873196328
Categories: 289,275,58,1,341,306,420

Place: B52 Cafe
Centrality: 0.018364669873196328
Categories: 496,158,636,173,162,641,362,1

Place: Naturoll Creamery
Centrality: 0.018146042850896372
Categories: 653,575,641,262,414

Place: Sienna Mercato
Centrality: 0.018146042850896372
Categories: 208,405,420,58,275,82,1

Place: Istanbul Sofra
Centrality: 0.018146042850896372
Categories: 891,447,79,1,158,189,641

Place: The Milk Shake Factory
Centrality: 0.017927415828596416
Categories: 641,653,838,575,262

Place: Senyai Thai Kitchen
Centrality: 0.01770878880629646
Categories: 1,620,631,370,83

Place: Eleven
Centrality: 0.01770878880629646
Categories: 1,420

Place: Kaya
Centrality: 0.017271534761696548
Categories: 1,58,275,64,817

Place: Fat Heads Saloon
Centrality: 0.016834280717096632
Categories: 1,275,604,58

Place: Tres Rios
Centrality: 0.016834280717096632
Categories: 208,275,1,651,58

Place: Umami
Centrality: 0.016834280717096632
Categories: 1,550,58,870,275

Place: Pittsburgh Poke
Centrality: 0.016834280717096632
Categories: 370,844,870,641,1,550

Place: Ten Penny
Centrality: 0.016834280717096632
Categories: 1,420,604

Place: Coca Cafe
Centrality: 0.016615653694796676
Categories: 162,641,1,370,173,420

Place: Mount Everest Sushi
Centrality: 0.016615653694796676
Categories: 550,1,870,217,641,844,861

Place: The Urban Tap
Centrality: 0.016615653694796676
Categories: 420,602,741,188,1,604,289

b- Compute a centralidade de intermediação e identifique os top 50 lugares de acordo com essa métrica. Mostre o nome e categorias dos lugares.

```
In [ ]: # Compute betweenness centrality  
compute centrality(nx.betweenness centrality)
```

Top 50 places according to centrality:

Place: Gaucho Parrilla Argentina

Centrality: 0.03831476818769258

Categories: 221,64,1,83

Place: Condado Tacos

Centrality: 0.03497635736098004

Categories: 1,393,275,208,58,651

Place: Noodlehead

Centrality: 0.031020182749383823

Categories: 370,1,620,641

Place: tākō

Centrality: 0.030039107496056698

Categories: 1,420,651

Place: Bakersfield

Centrality: 0.028527549889386276

Categories: 58,275,393,208,420,83,651,1

Place: Smallman Galley

Centrality: 0.024649600640238006

Categories: 275,604,420,173,1,58,641

Place: Meat & Potatoes

Centrality: 0.02246955292840512

Categories: 428,641,262,490,420,1,188

Place: DiAnoia's Eatery

Centrality: 0.020927805660861522

Categories: 1,287,289,405

Place: Piada Italian Street Food

Centrality: 0.017681677144784098

Categories: 741,1,405,46

Place: City Works - Pittsburgh

Centrality: 0.014176254796523331

Categories: 420,100,612,604,1,58,341,275

Place: Banh Mi & Ti

Centrality: 0.014017679656025113

Categories: 1,362,857,204,641

Place: Pork & Beans

Centrality: 0.013980383847038607

Categories: 604,1,208,612,58,275,437,706,133,641,289,613,330

Place: Southern Tier Brewery Pittsburgh

Centrality: 0.013117131217645933

Categories: 58,201,1,100,275,641,188

Place: Social House Seven

Centrality: 0.012841649260082352

Categories: 1,861,791,870,550

Place: Mindful Brewing Company

Centrality: 0.012117174470931379

Categories: 641,201,696

Place: Millie's Homemade Ice Cream
Centrality: 0.01177497110876863
Categories: 1,289,641,653

Place: The Abbey on Butler Street
Centrality: 0.0105944651083432
Categories: 275,420,362,641,1,58,173

Place: The Porch at Schenley
Centrality: 0.010533067455113182
Categories: 1,602,289,82,248,420

Place: Totopo Mexican Kitchen and Bar
Centrality: 0.010202102075161907
Categories: 275,1,64,58,651

Place: Burgh'ers Brewing
Centrality: 0.010028977954309303
Categories: 248,420,133,641,289,1,741,706,127,201

Place: Altius
Centrality: 0.009660654463966398
Categories: 133,641,1,275,5,58,420,575

Place: Ki Ramen
Centrality: 0.009650370461544242
Categories: 1,620,661,870,275,58

Place: Pirata
Centrality: 0.009515597959973416
Categories: 289,208,817,58,275,1

Place: Proper Brick Oven & Tap Room
Centrality: 0.009272353379603415
Categories: 405,641,696,58,1,82,275

Place: Primanti Bros
Centrality: 0.00920070286246742
Categories: 289,1,618,341,275,501,58,420

Place: Muddy Waters Oyster Bar
Centrality: 0.00858762974869714
Categories: 208,275,58,354,1,83

Place: Smoke BBQ Taqueria
Centrality: 0.008208112514518773
Categories: 1,613,248,651,393

Place: Butcher and the Rye
Centrality: 0.007938229467505454
Categories: 694,275,420,208,58,641,1

Place: Church Brew Works
Centrality: 0.007788981684635889
Categories: 275,1,58,201,604,575,641

Place: Everyday Noodles
Centrality: 0.007344171183672229
Categories: 631,620,791,1

Place: Naturoll Creamery
Centrality: 0.007136877715817585
Categories: 653,575,641,262,414

Place: B52 Cafe
Centrality: 0.007110053538962454
Categories: 496,158,636,173,162,641,362,1

Place: Central Diner & Grille
Centrality: 0.0070171334322083525
Categories: 891,594,604,83,1

Place: Primanti Bros
Centrality: 0.006832711151099599
Categories: 289,275,58,1,341,306,420

Place: Mount Everest Sushi
Centrality: 0.006829692914843712
Categories: 550,1,870,217,641,844,861

Place: Fat Heads Saloon
Centrality: 0.006602159215868419
Categories: 1,275,604,58

Place: Senyai Thai Kitchen
Centrality: 0.006592339921926931
Categories: 1,620,631,370,83

Place: Redhawk Coffee
Centrality: 0.0064989839079156635
Categories: 1,162,344,173,575,641

Place: Hofbrauhaus Pittsburgh
Centrality: 0.006398772332280343
Categories: 641,275,100,829,1,201,855,58

Place: Sienna Mercato
Centrality: 0.006354649098619648
Categories: 208,405,420,58,275,82,1

Place: Coca Cafe
Centrality: 0.006343999182561123
Categories: 162,641,1,370,173,420

Place: Deluca's Diner
Centrality: 0.006225860495430221
Categories: 162,594,604,1

Place: Mineo's Pizza House
Centrality: 0.006212516210440333
Categories: 653,82,575,1,405,641

Place: Pittsburgh Poke
Centrality: 0.006147771829679146
Categories: 370,844,870,641,1,550

Place: Istanbul Sofra
Centrality: 0.0060987680566871386
Categories: 891,447,79,1,158,189,641

Place: Kelly O's Diner
Centrality: 0.006032799999859968
Categories: 162,1,594,604

Place: Nicky's Thai Kitchen
Centrality: 0.00597512060471229
Categories: 370,575,1,83,496,641

Place: The Yard
Centrality: 0.005749348949567221
Categories: 420,58,1,188,275

Place: Tres Rios
Centrality: 0.005667580773900581
Categories: 208,275,1,651,58

Place: The Milk Shake Factory
Centrality: 0.005625789251873097
Categories: 641,653,838,575,262

c- Compute a centralidade de proximidade e identifique os top 50 lugares de acordo com essa métrica.

```
In [ ]: # Compute closeness centrality  
compute_centrality(nx.closeness_centrality)
```

Top 50 places according to centrality:

Place: Gaucho Parrilla Argentina

Centrality: 0.3386633071802575

Categories: 221,64,1,83

Place: tākō

Centrality: 0.3366922122688829

Categories: 1,420,651

Place: Condado Tacos

Centrality: 0.3361849274032173

Categories: 1,393,275,208,58,651

Place: Smallman Galley

Centrality: 0.3337425582725102

Categories: 275,604,420,173,1,58,641

Place: Bakersfield

Centrality: 0.33370690582530665

Categories: 58,275,393,208,420,83,651,1

Place: Noodlehead

Centrality: 0.33228702748970274

Categories: 370,1,620,641

Place: Meat & Potatoes

Centrality: 0.3320045005240403

Categories: 428,641,262,490,420,1,188

Place: DiAnoia's Eatery

Centrality: 0.33140572304590443

Categories: 1,287,289,405

Place: Pork & Beans

Centrality: 0.3218452859499995

Categories: 604,1,208,612,58,275,437,706,133,641,289,613,330

Place: Piada Italian Street Food

Centrality: 0.3211834613850191

Categories: 741,1,405,46

Place: Southern Tier Brewery Pittsburgh

Centrality: 0.3195407472821906

Categories: 58,201,1,100,275,641,188

Place: Social House Seven

Centrality: 0.3180118441851466

Categories: 1,861,791,870,550

Place: Pirata

Centrality: 0.3161771604686939

Categories: 289,208,817,58,275,1

Place: Banh Mi & Ti

Centrality: 0.3146802000030921

Categories: 1,362,857,204,641

Place: Altius

Centrality: 0.31449011833592017

Categories: 133,641,1,275,5,58,420,575

Place: Butcher and the Rye
Centrality: 0.3119774638400774
Categories: 694,275,420,208,58,641,1

Place: City Works - Pittsburgh
Centrality: 0.3104890513299568
Categories: 420,100,612,604,1,58,341,275

Place: The Milk Shake Factory
Centrality: 0.3101499548680198
Categories: 641,653,838,575,262

Place: Ki Ramen
Centrality: 0.3100268306302794
Categories: 1,620,661,870,275,58

Place: Millie's Homemade Ice Cream
Centrality: 0.3099653051627997
Categories: 1,289,641,653

Place: Primanti Bros
Centrality: 0.30965804375799916
Categories: 289,1,618,341,275,501,58,420

Place: Church Brew Works
Centrality: 0.30922889976546186
Categories: 275,1,58,201,604,575,641

Place: The Abbey on Butler Street
Centrality: 0.3081308291014693
Categories: 275,420,362,641,1,58,173

Place: The Urban Tap
Centrality: 0.3079182203480232
Categories: 420,602,741,188,1,604,289

Place: Proper Brick Oven & Tap Room
Centrality: 0.30785752886869966
Categories: 405,641,696,58,1,82,275

Place: Smoke BBQ Taqueria
Centrality: 0.3078271920999897
Categories: 1,613,248,651,393

Place: Muddy Waters Oyster Bar
Centrality: 0.3076755978952719
Categories: 208,275,58,354,1,83

Place: Primanti Bros
Centrality: 0.30710089907891225
Categories: 289,275,58,1,341,306,420

Place: Emporio: A Meatball Joint
Centrality: 0.30695001920317333
Categories: 58,405,641,275,575,420,116,1

Place: Pittsburgh Poke
Centrality: 0.3066186047733309
Categories: 370,844,870,641,1,550

Place: Ten Penny
Centrality: 0.30634797934987695
Categories: 1,420,604

Place: The Porch at Schenley
Centrality: 0.3062879052290122
Categories: 1,602,289,82,248,420

Place: Casbah
Centrality: 0.30518076840862596
Categories: 1,275,208,366,594,447,58,891,162

Place: Redhawk Coffee
Centrality: 0.3051211511457995
Categories: 1,162,344,173,575,641

Place: Deluca's Diner
Centrality: 0.30506155717096634
Categories: 162,594,604,1

Place: Senyai Thai Kitchen
Centrality: 0.3042296791420623
Categories: 1,620,631,370,83

Place: Eleven
Centrality: 0.30346127311353166
Categories: 1,420

Place: P&G's Pamela's Diner
Centrality: 0.3034317965449923
Categories: 289,162,1,594

Place: Everyday Noodles
Centrality: 0.3032844995563782
Categories: 631,620,791,1

Place: Burgh'ers Brewing
Centrality: 0.3028434653834896
Categories: 248,420,133,641,289,1,741,706,127,201

Place: Sienna Mercato
Centrality: 0.3025794600378434
Categories: 208,405,420,58,275,82,1

Place: Umami
Centrality: 0.30214047252448933
Categories: 1,550,58,870,275

Place: Coca Cafe
Centrality: 0.30193604730627255
Categories: 162,641,1,370,173,420

Place: Mindful Brewing Company
Centrality: 0.30187769089975797
Categories: 641,201,696

Place: Grist House Craft Brewery
Centrality: 0.3017318985251324
Categories: 201,641

Place: Central Diner & Grille
Centrality: 0.30141165046610335
Categories: 891,594,604,83,1

Place: The Yard
Centrality: 0.30097604253113935
Categories: 420,58,1,188,275

Place: Mount Everest Sushi
Centrality: 0.3008021517025224
Categories: 550,1,870,217,641,844,861

Place: The Vandal
Centrality: 0.2995617899338987
Categories: 1,420,366,362,275,818,162,173,49,248,58,289,641

Place: B52 Cafe
Centrality: 0.2995043475964233
Categories: 496,158,636,173,162,641,362,1

d- Compute a centralidade de autovetor e identifique os top 50 lugares de acordo com essa métrica.

```
In [ ]: # Compute eigenvector centrality  
compute Centrality(nx.eigenvector_centrality)
```

Top 50 places according to centrality:

Place: Gaucho Parrilla Argentina

Centrality: 0.17456964773391076

Categories: 221,64,1,83

Place: tākō

Centrality: 0.17190394434341297

Categories: 1,420,651

Place: Bakersfield

Centrality: 0.16320439180386453

Categories: 58,275,393,208,420,83,651,1

Place: Condado Tacos

Centrality: 0.16158529631224822

Categories: 1,393,275,208,58,651

Place: DiAnoia's Eatery

Centrality: 0.1587964106212814

Categories: 1,287,289,405

Place: Meat & Potatoes

Centrality: 0.15563920649505192

Categories: 428,641,262,490,420,1,188

Place: Smallman Galley

Centrality: 0.15546589064767946

Categories: 275,604,420,173,1,58,641

Place: Noodlehead

Centrality: 0.14667106736644028

Categories: 370,1,620,641

Place: Piada Italian Street Food

Centrality: 0.12540629451729368

Categories: 741,1,405,46

Place: Pork & Beans

Centrality: 0.11927850877329998

Categories: 604,1,208,612,58,275,437,706,133,641,289,613,330

Place: Social House Seven

Centrality: 0.11034424424220905

Categories: 1,861,791,870,550

Place: Southern Tier Brewery Pittsburgh

Centrality: 0.1084728239994891

Categories: 58,201,1,100,275,641,188

Place: Altius

Centrality: 0.10816173604755204

Categories: 133,641,1,275,5,58,420,575

Place: Banh Mi & Ti

Centrality: 0.10743793446039065

Categories: 1,362,857,204,641

Place: Pirata

Centrality: 0.10126009186547873

Categories: 289,208,817,58,275,1

Place: Millie's Homemade Ice Cream
Centrality: 0.09223361224484185
Categories: 1,289,641,653

Place: Butcher and the Rye
Centrality: 0.09090265042438088
Categories: 694,275,420,208,58,641,1

Place: Ki Ramen
Centrality: 0.08645310958256254
Categories: 1,620,661,870,275,58

Place: City Works - Pittsburgh
Centrality: 0.08509874766159922
Categories: 420,100,612,604,1,58,341,275

Place: Muddy Waters Oyster Bar
Centrality: 0.08470656013868523
Categories: 208,275,58,354,1,83

Place: The Milk Shake Factory
Centrality: 0.08423468799667166
Categories: 641,653,838,575,262

Place: Emporio: A Meatball Joint
Centrality: 0.08330441869027674
Categories: 58,405,641,275,575,420,116,1

Place: Primanti Bros
Centrality: 0.08216899268565812
Categories: 289,1,618,341,275,501,58,420

Place: Church Brew Works
Centrality: 0.0821183909290298
Categories: 275,1,58,201,604,575,641

Place: The Porch at Schenley
Centrality: 0.08130511616070686
Categories: 1,602,289,82,248,420

Place: Proper Brick Oven & Tap Room
Centrality: 0.08008226398598223
Categories: 405,641,696,58,1,82,275

Place: Ten Penny
Centrality: 0.07896841985416944
Categories: 1,420,604

Place: The Abbey on Butler Street
Centrality: 0.07865345500519726
Categories: 275,420,362,641,1,58,173

Place: Primanti Bros
Centrality: 0.07762003175898859
Categories: 289,275,58,1,341,306,420

Place: Eleven
Centrality: 0.07752353121402447
Categories: 1,420

Place: The Urban Tap
Centrality: 0.0771826970118795
Categories: 420,602,741,188,1,604,289

Place: Deluca's Diner
Centrality: 0.0763036776085501
Categories: 162,594,604,1

Place: Redhawk Coffee
Centrality: 0.07554424891924755
Categories: 1,162,344,173,575,641

Place: Senyai Thai Kitchen
Centrality: 0.07452161869403344
Categories: 1,620,631,370,83

Place: P&G's Pamela's Diner
Centrality: 0.07419377507801096
Categories: 289,162,1,594

Place: Smoke BBQ Taqueria
Centrality: 0.07328130843063049
Categories: 1,613,248,651,393

Place: Pittsburgh Poke
Centrality: 0.07189693835260806
Categories: 370,844,870,641,1,550

Place: Casbah
Centrality: 0.07082720310505877
Categories: 1,275,208,366,594,447,58,891,162

Place: Burgh'ers Brewing
Centrality: 0.06999146614649564
Categories: 248,420,133,641,289,1,741,706,127,201

Place: Sienna Mercato
Centrality: 0.06956160861906391
Categories: 208,405,420,58,275,82,1

Place: Umami
Centrality: 0.06883993743815056
Categories: 1,550,58,870,275

Place: Mount Everest Sushi
Centrality: 0.06807659474310286
Categories: 550,1,870,217,641,844,861

Place: Grist House Craft Brewery
Centrality: 0.06657709458887771
Categories: 201,641

Place: Everyday Noodles
Centrality: 0.0665006047957973
Categories: 631,620,791,1

Place: Coca Cafe
Centrality: 0.06513629353255714
Categories: 162,641,1,370,173,420

Place: B52 Cafe
Centrality: 0.06360998056079661
Categories: 496,158,636,173,162,641,362,1

Place: Monterey Bay Fish Grotto
Centrality: 0.0632887191678829
Categories: 208,366,58,83,275,1

Place: Casellula
Centrality: 0.0631066313101625
Categories: 366,420,275,612,1,58

Place: Istanbul Sofra
Centrality: 0.06309213401433779
Categories: 891,447,79,1,158,189,641

Place: Morcilla
Centrality: 0.06285859236663653
Categories: 562,1

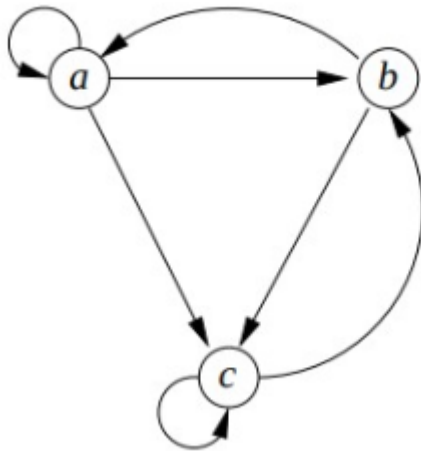
e- Interprete os resultados obtidos nas letras a, b e c. O que pode explicar as diferenças nos ranqueamentos? Dica, interprete o que a métrica captura. Esse resultado é inesperado de alguma forma?

- **Grau:** Captura o número de conexões de um nó. Lugares com alto grau de centralidade são aqueles com muitas conexões diretas. Isso pode indicar locais populares ou centrais na rede.
- **Intermediação:** Captura a frequência com que um nó aparece nos caminhos mais curtos entre outros nós. Lugares com alta intermediação são aqueles que estão no caminho entre muitos outros lugares. Eles podem atuar como pontos de trânsito ou de passagem na rede.
- **Proximidade:** Captura a distância média de um nó para todos os outros nós na rede. Lugares com alta proximidade são aqueles que estão mais próximos de todos os outros lugares na rede. Isso pode indicar locais facilmente acessíveis ou centrais em termos de distância.

Podemos notar que Gaucho Parrilla Argentina é o nó de maior centralidade em todos os resultados.

Sobre as diferenças nos ranqueamentos, elas podem ser explicadas pelas diferentes perspectivas que cada métrica captura. Por exemplo, um lugar pode ter muitas conexões diretas (alto grau de centralidade), mas não estar necessariamente no caminho entre outros lugares (baixa intermediação). Da mesma forma, um lugar pode estar próximo de todos os outros lugares (alta proximidade), mas não necessariamente ter muitas conexões diretas (baixo grau de centralidade). Portanto, é esperado que as diferentes métricas identifiquem lugares diferentes como os mais importantes, dependendo das características da rede e do que está sendo analisado.

2- Considere a seguinte rede e responda as questões abaixo.



a- O que acontece com as valores de PageRank dos nós conforme você aumenta o parâmetro de amortecimento (α) ?

Quando você aumenta o parâmetro de amortecimento (α), você está aumentando a probabilidade de o usuário continuar clicando nos links. No caso da rede ilustrada acima, como todos os nós estão interconectados, os valores de PageRank ainda tendem a ser distribuídos mais uniformemente pela rede. No entanto, os nós "a" e "c" podem ter um PageRank ligeiramente maior devido às auto-ligações.

b- O que acontece com as valores de PageRank dos nós quando o parâmetro de amortecimento (α) é 0? Explique a sua resposta.

Quando o parâmetro de amortecimento (α) é 0, isso significa que o usuário não clica em nenhum link e, em vez disso, salta para uma página da web aleatória em cada passo. No caso da rede ilustrada acima, como não há nós isolados e todos estão interconectados, os valores de PageRank seriam iguais para todos os nós, independentemente de quantos links de entrada eles têm. A única diferença é que os nós "a" e "c" podem ter um PageRank ligeiramente maior devido às auto-ligações.

3- Explique resumidamente a ideia de Hubs e Authorities no contexto de métricas de centralidade de rede.

No contexto de métricas de centralidade de rede, **Hubs** e **Authorities** são conceitos que se referem à importância de um nó na rede. Eles são interdependentes e foram inicialmente utilizados para modelar páginas da web.

- **Hubs:** Um bom hub é um vértice que aponta para muitos vértices com alto coeficiente de Authority. Ou seja, um hub é um nó que tem muitas conexões de saída para nós de alta qualidade.
- **Authorities:** Um bom Authority é um vértice que é apontado por muitos bons Hubs. Ou seja, uma autoridade é um nó que tem muitas conexões de entrada de nós de alta qualidade.

O algoritmo HITS (Hyperlink-Induced Topic Search) é frequentemente usado para calcular os coeficientes de Hub e Authority. Esses conceitos são particularmente úteis em redes direcionadas e acíclicas, onde a importância (ou centralidade) de um nó pode ser avaliada com base em quão bem ele atua como um hub (apontando para outros nós) ou uma autoridade (sendo apontado por outros nós). Essas métricas ajudam a identificar os nós mais importantes em uma rede.